

Remarks

This is in response to the Office Action mailed October 19, 2007, in the above-referenced application. Applicant notes with appreciation the acceptance of new Figures 5 and 6. Applicant also notes with appreciation the allowance of Claim 12.

New Claims 45-49 are added to highlight an exemplary embodiment of the invention. Claim 45 is directed to an improved semiconductor device including a conductive silicon carbide substrate; a conductive buffer layer on the silicon carbide substrate; a n-type Group III nitride layer on the buffer layer; a p-type Group III nitride layer that includes some gallium directly on the n-type layer to form a p-n junction; a first silicon dioxide layer on the p-type layer; a layer of a Group II metal source composition on the first SiO₂ layer; and a second SiO₂ layer on the Group II metal source composition layer. Claims 2 and 14 are also amended to state that the p-type layer and the n-type layer are adjacent one another to form a p-n junction. Support for this amendment can be found in the application as filed, for example, the figures and paragraph [0030].

Claim 46 further recites a magnesium source composition, and Claims 47-49 are directed to various devices including a plurality of silicon dioxide portions on the p-type Group III nitride layer, with a respective portion of the magnesium source composition on each silicon dioxide portion.

Entry and favorable consideration of new claims 45-49 are respectfully solicited.

By way of background, the present invention is directed to improved semiconductor devices having desirable properties, and in particular semiconductor devices including a p-type Group III nitride layer, such as a GaN layer. As discussed in the Background section of the application, it can be particularly difficult to activate p-type dopant atoms (such as magnesium) present in a p-type Group III nitride layer. Absent efficient activation of dopant atoms in the p-type Group III nitride layer, the p-type Group III nitride layer may have total concentration of dopant atoms that is higher than the activated concentration (or realized effect) of the dopant atoms.

Applicant has provided semiconductor devices which can exhibit improved dopant atom activation of a p-type Group III nitride layer. The device includes a p-type Group III nitride layer (which can already include p-type dopant atoms) in combination with a first silicon dioxide layer on the p-type layer, a layer of a Group II metal source composition on the first SiO₂ layer, and a second SiO₂ layer on the Group II metal source composition layer. The device structure can allow one to readily activate or increase the activation of the dopant atoms in the p-type Group III nitride layer. *See*, for example, paragraph [0033]. The present invention can also readily allow the creation of device including a p-type layer from a nominally n-type group III nitride layer to form a p-n junction. *See*, for example, Figures 3 and 4 and paragraphs [0055]-[0057].

Claims 1, 3-5, 8 and 10 are rejected under 35 USC Section 103(a) as unpatentable over Touchy (U.S. Patent No. 3,925,121) in view of Ogihara et al. (U.S. Patent No. 5,700,714, hereinafter Ogihara). Applicant respectfully traverses this rejection for the reasons of record.

Applicant also offers the following additional comments. Touchy states that its protective layer, which can be a silicon dioxide layer, allows Group III elements and dopant to diffuse through it. Accordingly, although Ogihara states that anneal cap 22 can be silicon dioxide, the skilled artisan would not modify the Touchy device to include a silicon dioxide “anneal cap” because the expectation would be that such an “anneal cap” would not function as such, that is, silicon dioxide would permit, not block, diffusion. Thus, the addition of a silicon dioxide “anneal cap” would actually be expected to decrease efficiencies by promoting loss of dopant from the device.

Further, the skilled artisan would avoid adding an additional layer, and certainly an additional layer that is not expected to be effective for the purpose stated by the Office. Stated differently, generally one would want to decrease the number of processing steps, particularly if the added step is not expected to impart any benefit.

Yet, the inventors have unexpectedly found that the presence of a second silicon carbide layer (a material which as taught by Touchy allows the passage of dopant)

surprisingly improves the activation of an underlying p-type Group III nitride layer and/or provides p-type group III nitride characteristics to portions of a n-type Group III nitride layer.

Accordingly, Applicant submits that the claimed invention is patentable over Touchy in view of Ogihara and respectfully request withdrawal of this rejection.

Claims 2, 9, 11 and 13 are rejected under 35 USC Section 103(a) as obvious over Touchy in view of Ogihara and further in view of Edmond et al. (U.S. Patent No. 5,523,589, hereinafter Edmond; Claim 2); Iguchi et al. (U.S. Patent No. 6,214,708, hereinafter Iguchi; Claim 9); and Nobori et al. (U.S. Patent No. 6,291,328, hereinafter Nobori; Claims 11 and 13). Applicant respectfully traverses these rejections for the reasons of record.

Applicant also offers the following additional comments. With regard to Claim 2, Touchy and Edmonds address different problems associated with different types of semiconductor devices. For example, Edmond addresses the problem of crystal lattice matching. In contrast, crystal lattice mismatch is not a problem for the Touchy device because the Group III-V substrate is itself doped. Accordingly, there is no motivation to combine the teachings of the Touchy and Edmonds patents.

Even if one were to combine the teachings of the Touchy and Edmonds patents (which Applicant submits there is no motivation to do), the result still would not be the same as claimed. The Touchy method directly dopes a single crystal Group III-V substrate. At best, one would substitute the SiC single crystal substrate of Edmond for the Group III-V single crystal substrate of Touchy. Yet such a device would differ significantly in function and structure from the claimed invention. Accordingly, Applicant submits that Claim 2 is patentable over the cited patents and respectfully requests withdrawal of this rejection.

With regard to Claims 11 and 13, the Touchy patent does not teach or suggest a device including a plurality of silicon dioxide portions on a p-type Group III nitride layer, with a respective portion of a source composition on each silicon dioxide portion. Touchy also teaches away from this embodiment of the invention, requiring application of a protective silicon dioxide layer over the entire surface of the substrate to be treated. Column 3, lines 10-11. This is consistent with the overall process of Touchy, in which the entire surface of the

substrate is exposed to a gaseous form of the dopant or to a “paint-on” or “spin-on” coating of dopant. There is simply no motivation to modify Touchy, alone or in combination with Nobori, to provide a device having a plurality of silicon dioxide portions with a respective portion of a source composition on each silicon dioxide portion, and to argue otherwise ignores or frustrates the functionality of the Touchy process.

Even if one were to modify the Touchy device to include a diffusion source of Nobori (which Applicant submits there is no motivation to do), the result still would not be the same as claimed. At best, the resultant device would still include a continuous layer of silicon dioxide on the entire surface of a monocrystal Group III-V substrate, and the Office does not argue otherwise.

Accordingly, Applicant submits that Claims 2, 9, 11 and 13 are patentable over the cited patents and respectfully requests withdrawal of these rejections.

Claims 1, 2, 7 and 14-18 are rejected under 35 USC Section 103(a) as unpatentable over Omi et al. (U.S. Patent No. 6,549,552, hereinafter Omi) in view of Touchy and Ogihara. Applicant respectfully traverses this rejection as well for the reasons of record.

In addition, Applicant respectfully submits that even if the modification proposed by the Office were made (which Applicant submits there is no motivation to do), the result still would not be the same as claimed. The Omi device includes a non-doped active layer 14 disposed between layers 3 and 9 of Figure 1 (relied upon by the Office). In contrast, Claims 2 and 14 state that the device includes adjacent p-type and n-type layers forming a p-n junction. Thus the Omi device teaches away from a device as claimed having a p-n junction and requires instead a non-doped layer disposed between n-type and p-type layers.

Further, the various p-type and n-type layers of the Omi device have various specific functionalities, such as cladding layers (layers 3, 5), light absorption (layer 17) and contact layer (layer 9). Thus, even if one were to ignore Omi’s explicit requirement of an intervening non-doped layer, the functionality of the remaining various layers of the Omi device differs significantly from that of the claimed invention. Accordingly, Applicant submits that Claims

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1, 2, 7 and 14-18 are also patentable over the cited patents and respectfully requests withdrawal of these rejections.

In view of the foregoing, Applicant submits that Claims 1-5, 7-18, and 45-49 are patentable and respectfully requests withdrawal of the rejections of record. Applicant respectfully submits that the present application is in condition for allowance, which action is respectfully solicited. Should the Examiner have any questions regarding the foregoing, it is respectfully requested that the Examiner contact the undersigned at his convenience to expedite examination and allowance of this matter.

It is not believed that extensions of time or fees for net addition of claims are required beyond those that may otherwise be provided for in documents accompanying this paper. However, in the event that additional extensions of time are necessary to allow consideration of this paper, such extensions are hereby petitioned under 37 CFR § 1.136(a), and any fee required therefore (including fees for net addition of claims) is hereby authorized to be charged to Deposit Account No. 50-0332.

Respectfully submitted,
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